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The paranasal sinusitis in the CT and MRI and in the CT/MR digital fusion images

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Summary

Background: The aim of the study is to evaluate the CT and MR visualization of the sinusitis. The second focus is to investigate usefulness of digital fusion of these examinations.

Material/Methods: 28 patients with suspicion of the sinusitis underwent the CT and MR exams. Finally the CT/MR digital fusion of all the examinations, using the own program, was performed. Evaluation of the quality of imaging the bones, soft tissues and mucosa was applied in all the techniques.

Results: Both the modalities well depicted the soft and mucosal elements with a slight superiority of MR in imaging the discrete mucosal thickening. The small bones were better presented in CT. The fused images correctly depicted even the discrete mucosal changes on the background of small bony structures.

Conclusions: CT better presented bone elements of sinuses; MR is slightly superior in imaging the mucosal thickening. Their digital fusion unified the advantages of both.

Key words: sinusitis • magnetic resonance imagining • computed tomography • digital fusion

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Background

In radiological practice the latest technology enables more and more precise localization and removal of pathologic changes, also by means of endoscopic procedures in nasal sinuses. Endoscopic surgery of sinuses does not only provide treatment of chronic sinusitis or nasal polyps. It is also applicable to malignant lesions in nasal and sinus cavities and frontal part of cranial basis. Some lesions, in cases where craniotomy was performed, can be operated with a cross-sinus method using an endoscope. Therefore, necessary pre-operative examinations include computed tomography (CT) and more and more often- magnetic resonance (MR), as they allow widening of the area of intervention by anterior cranial fossa, orbits and pituitary gland [1-5]. The indications for these techniques are: re-operations of sinuses, disease processes in frontal sinuses, posterior ethmoid and sphenoid sinuses, massive nasal and sinus polyps, disease lesions in cranial fossa, orbit, optic nerve or carotid artery, developing postoperative or posttraumatic disorders of anatomic structure of sinuses, neoplasms in nasal and sinus cavities, leakage of cerebrospinal fluid or disease processes discontinuing the cranial basis. The improvement in scanning techniques increased the resolution, while introduction of spiral and, lately, multislice CT reduced the time of examination and limited artifacts caused by patient's movement. CT of nasal sinuses is particularly useful in cases where the diagnosis is based on

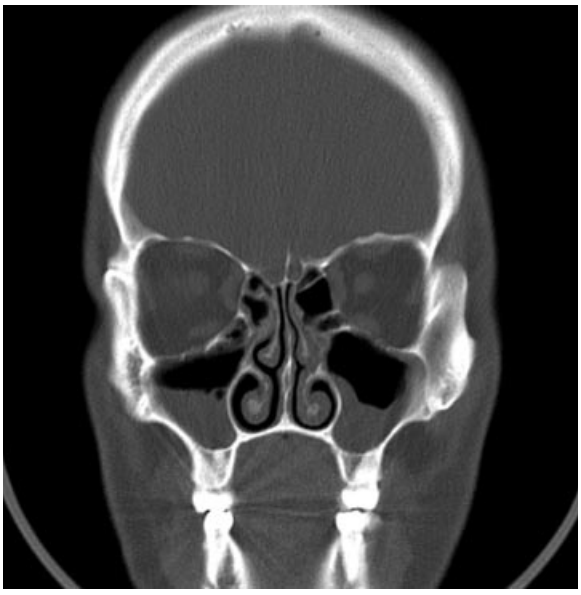


Figure 1. CT in frontal plane – fluid level in the right maxillary sinus (patient in prone position), prominent mucosal thickening in the left maxillary sinus and ethmoid.

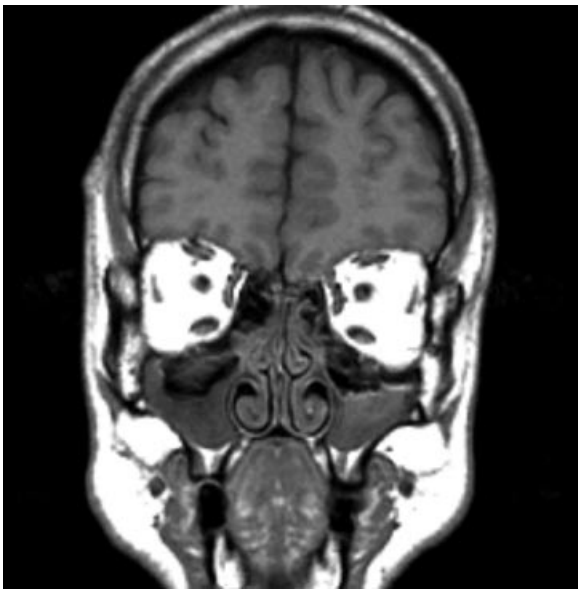


Figure 2. The same patient in MR – good delineation of the mucosal changes, fluid and soft tissues of the face; small bony elements the sinuses, especially ethmoids, are worse depicted.

evaluation of changes in osseous structures (structure anomalies, neoplastic or inflammatory infiltration within the bones of cranioface) [6, 7].

However, magnetic resonance has a better capability of imaging soft tissues of the cranioface and mucosal lesions in sinuses [8-10]. In the course of treatment of chronic sinusitis many patients need to undergo follow-up CT examinations several times, what means that they are additionally exposed to ionic radiation which is always potentially dangerous, especially that the area of examinations includes the orbits. The progress of computer techniques including fusions of CT and MR allows limiting the use of X radiation. Follow-up examinations performed in course of treatment or postoperatively can only be made using MR and the obtained pictures of soft tissues can be integrated with bone images from the initial CT which are therefore the unchangeable bone scaffold for the changing images of mucosal lesions [11, 12]. The aim of this work is to investigate the diagnostic utility of CT and MR imaging and their secondary fusions performed using own software for the assessment of sinusitis changes.

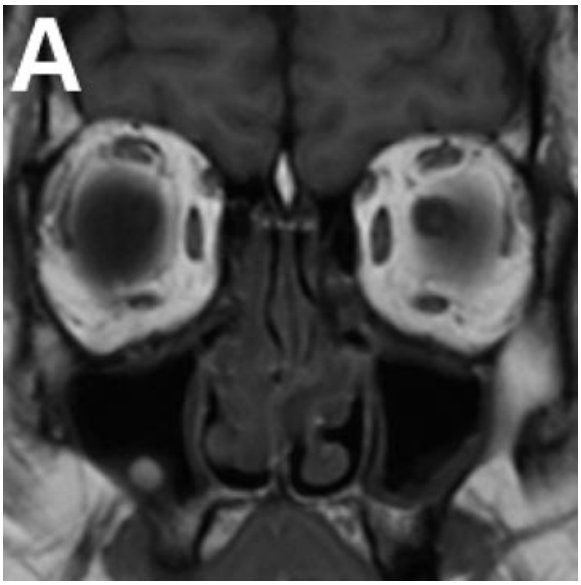
Figure 3. The digital fusion of the two previous images: the proper visualization of the spatial relationship of the delicate bony structures, better seen in CT, and soft tissues, better delineated in MR.

Materials and methods

The material comprised examinations of 28 patients (16 men, 12 women, age: 18-52) with suspicion of chronic sinusitis. All patients were examined wit CT and MR according to clinical indications. CT was carried out as the first one (Picker PQ5000 scanner) with a standard protocol for craniofacial examination: in frontal plane- perpendicular to hard palate, with sequence technique, slice thickness 5 mm. MR examinations were performed right after CT using Siemens Magnetom 1.5 T unit, in T1-weighted imaging (TR:600 ms, TE:14 ms), head coil, in frontal planes- parallel to the plane of CT examination, within bone structures- sphenoid sinus, slice thickness: 5 mm. MR exams underwent digital fusion with CT images using the own software- Dental Studio, installed on PC computer. The software superimposes pictures in form of bit maps by using an algorithm of best spatial fitting (detailed characteristics of the software and methodology of computer processing is available by the authors).

All CT and MR examinations, as well as images of other fusions, were evaluated subjectively and independently by two experienced radiologists (M.O., B.W.) according to the following criteria:

- Visualization of osseous structures in nose, ethmoid, sinuses and orbits



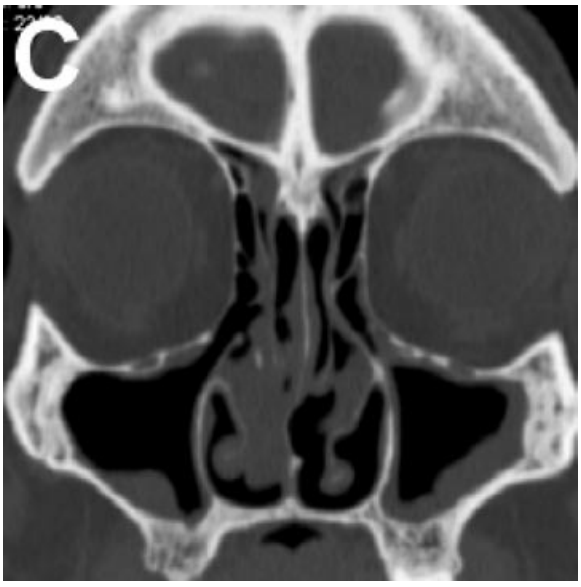


Figure 4. The fungal lesion in the right maxillary sinus: of a high signal intensity in the T1-weighted image – **A**, low signal intensity in the T2-weighted image – **B**, not distinguishable from mucosal thickening in CT – **C**.

- Visualization of soft tissue structures and mucosa in that region
- Visualization of pathological changes: thickening of mucosa, polyps, fluid

We used a 5-grade scale of quality of visualization of the examined structures and pathological changes:

1 – invisible
2 – hardly visible
3 – fairly visible
4 – well visible
5 – very well

Moreover, occurrence and influence of artifact on the image-mainly associated with dental materials.

Results

CT scans revealed signs of inflammatory changes in nasal sinuses (thickened mucosa, polyps, cyst, fluids) in 25 patients (fig. 1); in 18 patients it concerned frontal sinuses, in 21 – maxillary sinuses, in 23- ethmoid cells, sphenoid sinus in 10 and nasal cavities in 28 patients. Examinations of 3 patients, except for small thickening of mucosa in nasal cavities, showed no lesions. Compared to MR examination, CT scans had an advantage in visualization of osseous anatomical elements, especially ethmoid cells and orbital fossa. MR examination proved to be as effective as CT in imaging anatomy of nasal cavities, lateral wall of maxillary sinus and orbital walls. MR imaging shows soft-tissue elements in the study area more precisely than CT, especially intraorbital fat and eyeball muscles (fig. 2). As for pathology imaging, both methods showed compatibility concerning identification, localization and definition of lesion size, with distinct predominance of MR in revealing minimal mucosa thickening in sinuses and fungal vegetations (fig. 4). CT/MR fusion images allowed spatial correlation of picture of small osseous elements – perfectly seen in CT and insufficiently in MR- with soft tissue structures and mucosa changes, which are better visualized in MR (fig. 3). Detailed information can be found in table 1. Artifacts dependent on materials and dentures proved to be more visible in CT imaging.

Discussion

MR is considered to be a better method of imaging the structures containing fluids, fat and muscles than computed tomography due to higher contrast resolution within soft tissues. For example, in posttraumatic lesions it is indispensable for evaluation of contents and condition of the tissues in sinuses, nasal cavities and orbits [8-10]. Also the tissues affected by inflammation can be differentiated with primary tumors and metastases based on the

Table 1. The quality of the sinuse visualization in the CT, MR and fused images, according to the 5-grade scale.

Liczba pacjentów 28		Zatoka czołowa	Zatoka szczękowa	Zatoki sitowe	Zatoka klinowa	Jama nosa	
		18	21	23	10	28	
Jakość wizualizacji wg. skali 5 stopniowej	Struktur kostnych	5	5	5	5	5	TK
		2	4	2	2	4	MR
		5	5	5	5	5	fuzja
	Elementów miękkotkankowych i śluzówkowych	4	5	4	5	5	TK
		5	5	5	5	5	MR
		5	5	5	5	5	fuzja

differences in the intensity of resonance signal. MR is also more specific than CT in identification of fungal vegetation (fig. 4). The possibility to assess pathologic tissues, e.g. intraorbital, in Grave's disease and predicting susceptibility to treatment is valuable [13]. What is even more valuable is the possibility to evaluate the soft tissues inside the nasal sinuses which are in contact with the orbital walls (maxillary sinus, ethmoid, frontal sinus). According to our experience with MR, the interpretation of soft-tissue pathology within the face is easier and more complete comparing to the CT scan [8]. However, it should be remembered that a complete image includes also the osseous elements, especially small- visualized most completely and directly using the CT method. The small bone structures of craniofacе could also be visible in MR image with worse quality and indirectly based on the rule of contrast in gray scale between adjacent osseous structures (non-signal) and soft-tissue (usually high signal).

Therefore, secondary digital fusion of CT and MR images is a valuable supplement for diagnostics of this region which enables spatial correlation of bone elements on one result image- visible better in CT, and soft tissue- better visualized in MR. Our own experience, as well as experience of other authors, show that comprehensive radiological evaluation of soft tissues of face and sinuses facilitates planning the treatment, including surgical procedures [2, 3, 7, 8]. In many patients with chronic sinusitis follow-up CT was repeated several times in order to monitor the condition of changes in mucosa. According to our evaluation the use of MR technique for that purpose is more beneficial as it does not burden the patient with ionic radiation. Images of following MR examinations can be superimposed using digital fusion to primary CT examination of the patient in whom it is possible to assess the possible anomalies in osseous structure of sinuses leading to inflammatory lesions. High cost and limited accessibility still hinders the popularization of MR imaging.

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